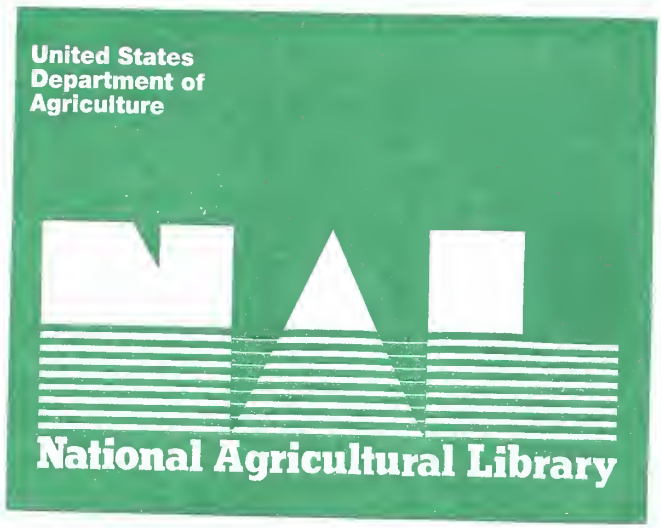
ARS Pollination Research Workshop

Denver, Colorado
October 16-17, 1991

Agricultural
Research
Service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EXECUTIVE SUMMARY

The USDA Agricultural Research Service (ARS) convened a Pollination Research Workshop in Denver, Colorado, October 16-17, 1991, to determine priorities for current and future research. Workshop invitees were selected to represent ARS and university research scientists, the beekeeping industry, and grower and commodity groups.

> *The objectives of the workshop were to: 1) Assess the status of ARS pollination research programs; 2) Establish priorities for ARS pollination research; 3) Identify appropriate locations at which to pursue ARS pollination research; and 4) Foster continuing dialogue and cooperation among those with an interest in pollination research representing ARS, universities, the bee industry, and other constituent groups.*

Research thrusts were identified through a series of working groups organized into the following broad areas: Management, Behavior, Diseases and Pests, Genetics and Breeding, Biosystematics, and Plant Systems. The highest priority items (not necessarily in priority order) were:

> ***Develop means to mitigate the impact of Africanized honey bees on crop pollination.***
>
> ***Develop methods for the commercial production of non-<u>Apis</u> pollinators.***
>
> ***Develop improved guidelines for the use of bees as pollinators.***
>
> ***Improve the quality and quantity of pollinators by reducing the impact of bee diseases, parasites, and pests.***
>
> ***Develop improved breeding schemes to increase the commercial fitness of honey bee stocks.***
>
> ***Develop components of genetic engineering technology for honey bees with the ultimate goal of genetically transforming honey bees.***
>
> ***Develop native and exotic bees as crop pollinators by exploiting relevant aspects of their ecology and biology.***
>
> ***Determine the pollination requirements and mechanisms essential for maximizing productivity in crop systems.***
>
> ***Identify and enhance the contributions of bees to the propagation of non-crop plants.***

Specific approaches within these and other research thrusts, as well as appropriate ARS research locations at which to pursue them, were identified. Finally, a set of Recommendations (not directly research-related) was developed.

INTRODUCTION

The value of bee pollination in crop production has been estimated at $10-20 billion per year. Production of some crops is totally dependent on bee pollination, and since crop producers typically operate with a small profit margin, there is a constant need for more cost-effective crop pollination systems.

The Africanized honey bee and parasitic honey bee mites will present beekeepers and crop producers with increased pollination costs and new management challenges. The honey bee is used for the pollination of many crops, but it may not be the most efficient pollinator for some crops. Non-*Apis* bees have proven value in some crop systems, but have unexplored potential in many others.

ARS has a strong commitment to improve the use of honey bees as crop pollinators and to develop alternative pollinators. Because of the likelihood of no increase in research budgets in the future, priorities must be set to make the most efficient use of available resources.

ARS seeks and depends upon key representatives of the pollination research community to help establish research priorities. Consequently, workshop invitees represented a broad range of the following groups: ARS and university research scientists, the beekeeping industry, and grower and commodity groups.

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The agenda for the workshop is shown in Appendix 1. Participants (Appendix 2) were assigned to working groups to identify future ARS research directions. These eight groups then developed research priorities and approaches. These groups covered the following areas: orchard and fruit crops, vegetable crops, field and oilseed crops, pollinator management, behavior, diseases and pests, biosystematics, and exploration and importation. On the second day the entire group identified broad research areas and established priorities and approaches.

On the following pages, research priorities are defined within one of several broad categories: Management, Behavior, Diseases and Pests, Genetics and Breeding, Biosystematics, and Plant Systems. Each priority is identified as high, intermediate, or low, and, in many cases, particular approaches are given. For each priority item, appropriate ARS bee lab locations (where work is ongoing or should begin) are listed parenthetically. Many priorities took the form of recommendations, that is, problems not able to be solved by research and thus beyond the scope of the mission of ARS. These are listed without prioritization.

This report will be used to identify high-priority needs and to develop new research initiatives. The target audience includes administrators and researchers within agencies of the USDA, representatives of the beekeeping and

pollination industries, regulatory officials at local, State, and Federal levels, and university scientists and cooperators.

The Workshop Steering Committee consisted of: R. Bram, A. Collins, E. Erickson, T. Rinderer, H. Shimanuki, and J. Vandenberg, Chair. R. Danka, T. Griswold, T. Hansen, and P. Kral also helped prepare the report. Additional copies of this report may be obtained from J. Vandenberg.

MANAGEMENT

Efficient management of bee populations for crop pollination is one of the major determining factors in successful crop production. Research on bee management is a multifaceted field which is currently being studied by ARS scientists. This commitment should continue and should be strengthened. A key to successful management is to maintain healthy colonies. With the invasion of the Africanized honey bee, colony management for pollination may become problematic. The use of non-Apis bees for crop pollination is, in some cases, limited by the inability to produce commercial quantities of them. Beekeepers and crop producers will benefit from standardized management guidelines to meet crop pollination needs.

High Priority

Reduce the impact of diseases, parasites, and pests of bees used for pollination. (Baton Rouge, Beltsville, Logan with cooperators, Tucson, Weslaco with cooperators)

Particular priorities are detailed below (in Diseases and Pests).

Develop methods for the commercial production of non-Apis pollinators. (Beltsville, Logan)

With an expanding potential role in crop pollination, technology must be developed for the culture, mass production, and efficient delivery to users of appropriate non-Apis species.

Develop improved guidelines for the use of bees as pollinators. (Logan, Tucson, Weslaco with cooperators)

Specific requirements (usually numbers of honey bee colonies per acre) are needed when using bees to pollinate target crops. These critical guidelines should also include the quality, timing of introduction, and placement of pollinators. Conjunctively, means of quality assessment of bee populations need to be developed for crop growers who rent bees for pollination.

Intermediate Priority

Identify pollinator complexes and management effects on pollinator efficiency. (Logan with cooperators, Tucson, Weslaco)

Specific approaches would be directed at the few species of bees for which commercial management schemes exist. These include documentation of the interactions among Apis and non-Apis pollinators and a determination of the potential for management of multiple species for enhanced pollination. Selected native and exotic bees as potential crop pollinators should also be investigated.

Develop economic evaluations of pollination-related management. (Beltsville with cooperators, Logan, Tucson; and in cooperation with USDA-ERS, see p. 13)

This should include all economic aspects of the pollination industry -- returns for growers and feasibilities and returns for beekeepers.

BEHAVIOR

An understanding of the way a bee behaves as a pollinator, whether through individual actions or interactions within a group, is integral to the development of management or breeding techniques. The impact of diseases and parasites on the efficiency of pollinators will be realized, in part, by their effects on the behavior of the bees. Behavioral differences may become a part of the identification of species or types within a species.

High Priority

Determine and mitigate the impact of the Africanized honey bee on crop pollination. (Baton Rouge, Tucson, Weslaco, and in conjunction with CSRS Regional Project W-180)

The presence of the Africanized honey bee may have significant impact on pollination: by reducing pollinator diversity, through interactions with other pollinators during plant visitation, or changing the contribution of feral honey bee colonies to pollination.

Intermediate Priority

Determine the foraging behaviors and pollination efficiencies of pollinators. (Baton Rouge, Beltsville, Logan, Tucson)

At the population level, this includes species range and distribution, recruitment of individuals to a crop, and the impact of abiotic and biotic factors on pollination efficiency. For individuals, specific behavioral traits related to pollination need study, such as: activity cycles, response to rewards, working patterns in the field and on flowers, and foraging distance. Comparative studies of Africanized and European honey bees, non-Apis bees, and flies as pollinators are warranted. The use of standardized methodology (e.g., Spear's pollination efficiency index) is needed for proper comparisons.

Develop methods for the chemical mediation of pollination behavior. (Beltsville, Logan, Tucson)

Pertinent research areas include: evaluation of, and delivery systems for, various repellents, attractants, or stimulants; response thresholds and physiologic factors; promotion of non-Apis nest aggregations; and pre-imaginal conditioning of non-Apis bees for pollination of specific crops.

Determine the impact of interspecific interactions among pollinators. (Beltsville, Logan, Weslaco)

This topic is also highlighted in the search for native pollinators or complexes of species for specific crops. The interaction of Apis

and non-*Apis* species in a broader scope than just with Africanization is included here.

Determine effects of pesticides, especially sublethal effects, on pollinators. (Tucson)

Nuances of pesticide-pollinator interactions need to be critically examined with regard to pollination efficiency. Although historically there have been periodic investigations in this area, a more thorough and systematic effort is needed.

Low Priority

Conduct research to determine the benefits and costs of importation of *Apis cerana* into the United States. (Beltsville with cooperators)

This work would include identification of exotic diseases and pests associated with *A. cerana*, evaluation of *A. cerana* ecotypes, development of a list of plants visited by *A. cerana*, and development of management strategies specific for *A. cerana*.

DISEASES AND PESTS

One of the major limitations to population buildup of pollinators is the impact of diseases and pests. In the last 25 years, two exotic mite parasites of the honey bee (the tracheal mite and the varroa mite) and chalkbrood of the alfalfa leafcutting bee and of the honey bee have been discovered in the United States and have become widespread. More recently, the Africanized honey bee has become established in Texas. ARS research programs must be initiated to reduce the impact of the mites, diseases and Africanized honey bees on the availability and quality of bees for pollination.

High Priority

Develop integrated pest management techniques for the control of the honey bee tracheal mite, the varroa mite, and chalkbrood. (Baton Rouge, Beltsville, Tucson, Weslaco)

Develop integrated control methods for diseases and pests of leafcutting bees, including chalkbrood, pollen mass, and parasitoids. (Logan with cooperators)

Evaluate the impact of virus diseases on honey bees. (Beltsville)

Intermediate Priority

Study host-parasite interactions to develop improved control methods for diseases and pests of bees other than the honey bee and the alfalfa leafcutting bee. (Logan)

GENETICS AND BREEDING

The pollination of crops using honey bees is primarily dependent upon the availability of populous healthy colonies. Ideally, such colonies are resistant to the hazards of diseases and pests and have general fitness levels suited to a variety of environments. Such colonies will produce numerous healthy foragers that will pollinate, even in sub-optimum weather conditions. Honey bee stocks can be improved in these areas through breeding and genetic research which will improve bee characteristics, especially in the face of diseases, parasites, and other unfavorable ecological conditions. Classical quantitative, population genetic, and molecular biological approaches are appropriate to achieve the high-priority goals.

High Priority

Develop strains of honey bees that show resistance/tolerance to the honey bee tracheal mite, the varroa mite, chalkbrood, and general environmental stress. (Baton Rouge)

Develop improved breeding schemes to increase the biological and commercial fitness of honey bee stocks to overcome identified pollination problems. (Baton Rouge)

Develop components of genetic engineering technology for honey bees with the ultimate goal of genetically transforming honey bees. (Baton Rouge)

BIOSYSTEMATICS

Proper identification is fundamental to all other research endeavors. Systematics research provides the framework for these identifications. Systematic and natural history studies of bees and their hosts are essential: There are over 20,000 bee species, many of which are potential pollinators.

High Priority

Determine relevant aspects of the ecology and population biology of candidate pollinators. (Beltsville, Logan, Tucson)

Knowledge of individual species in their native habitat provides the critical baseline information needed for successful pollinator management. Determination of distribution and diversity of candidate pollinators, and the environmental constraints on their populations, will facilitate their ultimate management as crop pollinators. Target pollinator species may then be denoted for future management.

Intermediate Priority

Provide a systematic framework for the identification of potential pollinators. (Baton Rouge, Beltsville, Logan)

Develop identification manuals and biosystematic revisions of bee genera at the species level to provide the foundation for accurate correlation of basic biological and ecological parameters with correct species. Develop a computerized catalog of native bees (to include distribution, floral relationships, nesting habits, seasonality, etc.). Develop sub-specific identification methods for honey bees using molecular systematics techniques.

PLANT SYSTEMS

The role of insects in transferring pollen to initiate the fertilization process in plants is well known, as are the pollination requirements of some economically important plant species. Insect pollinators are crucial to the production of most fruit, nut, and seed crops. Not as well known are the contributions of pollinators to biodiversity, conservation, and wildlife preservation in non-crop ecosystems. Little is known about how floral cues are used by individual bees to choose pollen and nectar sources within plant communities. The factors that affect the ability of bees to acquire and effectively distribute pollen become especially important in the development of hybrid crop systems and those involving self-incompatible cultivars. Research is needed to determine those factors which contribute most to the goal of maximizing the efficiency of reproduction in both crop and non-crop plant systems. The results of this research will significantly increase crop productivity and the associated economic return. This research will also contribute greatly to ecosystem stabilization in uncultivated areas.

High Priority

Develop knowledge of the pollination requirements and mechanisms essential for maximizing productivity in crop systems. (Beltsville, Logan, Tucson, Weslaco with cooperators)

Determine the pollination requirements of selected insect-pollinated crop species based on relative economic importance. Determine the significance of cross-pollination on the quantity and quality of fruit and seed produced. Determine the potential contribution of honey bees in enhancing pollination of selected wind-pollinated crops.

Determine the contribution of bees to the propagation of non-crop plants. (Beltsville, Logan, Tucson)

Determine the pollination requirements of endangered plant species. Determine the contribution of bees to the vigor of plant populations important for soil stabilization and for the survival of endangered wildlife.

Intermediate Priority

Develop pollination strategies tailored to hybrid and specialty crop systems. (Beltsville, Tucson, Weslaco)

Determine essential, crop-specific, pollinator foraging cues and assist plant breeders in the incorporation of these cues into their hybrid seed parent lines. Identify and develop appropriate pollinators for hybrid crop systems. Develop pollinator management strategies for selected hybrid crop systems.

Determine the intrinsic pollinator foraging cues presented by flowers as

well as the relative importance of these cues. (Baton Rouge, Logan, Tucson)

Identify, evaluate, and rank floral characters that influence foraging by bee pollinators. Determine the breadth of qualitative differences among genotypes for these floral characters in selected crop systems. Develop measures of individual bee-pollinator efficiency.

RECOMMENDATIONS

Workshop participants identified several priority areas that, for various reasons, are unable to be addressed through research done by ARS. These take the form of recommendations directed to one or more other agencies (identified in parentheses). No priority order was assigned to these recommendations.

Organize a Technical Advisory Group to develop uniform criteria for the importation of pollinators into the United States and for the minimization of the risks to U. S. agriculture of such importations. (USDA-APHIS)

Support the National Genetic Resources Program on Insects and Other Arthropods, including the development of a Honey Bee and Other Pollinator Stock Center for initial evaluation of native and introduced pollinators.

Develop economic evaluations of crop/pollinator systems. (USDA-ERS, university cooperators)

Include the ability of a cultivar to attract/support pollinators as a factor in plant-breeding research. (other ARS programs, university cooperators)

Provide continuing education for growers on the role of pollinators in crop-management systems (including pesticide issues). (USDA-ES)

Consider bee safety during the pesticide re-registration process and include development of protocols to test the safety of pesticides for bees. (USEPA)

Tighten reporting requirements of pesticide use and tank mix composition. (USEPA and appropriate state agencies)

Develop a reporting system for bee losses due to pesticides. (USDA-APHIS, USDA-ES, NASDA, State agencies,)

A copy of this report will be sent to the identified agencies with the request that they consider implementation of the following recommendations.

APPENDIX 1: AGENDA

Wednesday October 16, 1991

8:00 a.m.	Welcome and Introductions (Army, Bram)	
8:30	Overview of Programs and Interests of All Participants	
9:30	Overview of ARS Bee Lab Programs (RLs and Lead Scientists)	
9:55	Workshop Format (Vandenberg)	
10:00	BREAK	
10:30	Working Group I:	CROPS (Orchard and Small fruits; Vegetable crops and seeds; Field crops and seeds and Oilseeds; New crops, Pollinator exploration and introduction)
12:00	LUNCH	
1:00 p.m.	Working Group I:	Reports and Discussion
2:00	Working Group II:	POLLINATORS (Management; Behavior; Biosystematics; Diseases, Pests, and Pesticides)
3:30	BREAK	
4:00	Working Group II:	Reports and Discussion
5:00	END	

Thursday October 17, 1991

8:00 a.m.	Discussion of Working Group Sessions
9:00	Discuss and Prioritize Research Objectives
10:00	BREAK
10:30	Discuss and Prioritize Research Objectives
12:00	ADJOURN
1:00 p.m.	Steering Committee Outlines and Drafts Report
3:00	END

APPENDIX 2: PARTICIPANTS

Mr. R. Adee	American Honey Producers' Association, Box 368, Bruce, SD 57220, (605) 627-5621
Dr. T. Army	USDA ARS, Director, Northern Plains Area, 2625 Redwing Road - Suite 350, Fort Collins, CO 80526, (303) 229-5557
Dr. S. Batra	USDA ARS, Bee Research Laboratory, Bldg. 476 BARC-East, Beltsville, MD 20705, (301) 504-8205; FTS 964-8205
Dr. R. Bitner	Northwest Alfalfa Seed Growers Assn, 16647 Plum Lane, Caldwell, ID 83605, (208) 454-0086
Dr. R. Bram	USDA ARS, National Research Program Leader, Bldg. 005 BARC-West, Beltsville, MD 20705, (301) 504-5771; FTS 964-5771
Dr. S. Buchmann	USDA ARS, Honey Bee & Insect Research Unit, Carl Hayden Bee Research Center, 2000 E. Allen Road, Tucson, AZ. 85719, (602) 670-6380; FTS 762-6380
Dr. A. Collins	USDA ARS, Honey Bee Research Unit, Subtropical Agric. Research Laboratory, 2413 E. Highway 83 Building 205, Weslaco, TX 78596, (512) 969-4870
Dr. R. Danka	USDA ARS, Honey Bee Breeding Lab, 1157 Ben Hur Road, Baton Rouge, LA 70820, (504) 766-6064; FTS 687-0277
Dr. A. Dietz	USDA APHIS, Federal Building RM 816, 6505 Belcrest Road, Hyattsville, MD 20782, (301) 436-8716
Dr. E. Erickson	USDA ARS, Honey Bee & Insect Research Unit, Carl Hayden Bee Research Center, 2000 E. Allen Road, Tucson, AZ 85719, (602) 670-6380; FTS 762-6380
Dr. R. Fell	Entomology Department, Virginia Poly. Inst. & State University, Blacksburg, VA 24061, (703) 231-6341
Dr. T. Griswold	USDA ARS, Bee Biology and Systematics Lab., Utah State University, Logan, UT 84322-5310, (801) 750-2524
Dr. C. Gupton	USDA ARS, U. S. Small Fruits Research Station, P. O. Box 287 - 306 S. High, Poplarville, MS 39470, (601) 795-4030
Mr. J. Haefeli	American Beekeeping Federation, 3729 North RD 3 West, Monte Vista, CO 81144, (719) 852-3149
Dr. G. Hoffman	USDA ARS, Honey Bee & Insect Research Unit, Carl Hayden Bee Research Center, 2000 E. Allen Road, Tucson, AZ 85719, (602) 670-6380; FTS 762-6380

Dr. G. Loper	USDA ARS, Honey Bee & Insect Research Unit, Carl Hayden Bee Research Center, 2000 E. Allen Road, Tucson, AZ 85719, (602) 670-6380; FTS 762-6380
Dr. J. Payne	USDA ARS, S. E. Fruit & Tree Nut Research Lab., P. O. Box 87, Byron, GA 31008, (912) 956-5656; FTS 238-0421
Mr. S. Rawlins	American Farm Bureau Federation, 225 Tuohy Avenue, Park Ridge, IL 60068, (312) 399-5747
Dr. T. Rinderer	USDA-ARS Honey Bee Breeding Lab, 1157 Ben Hur Road, Baton Rouge, LA 70820, (504) 766-6064
Dr. H. Shimanuki	USDA-ARS, Bee Research Lab, BARC-East Bldg. 476, Beltsville, MD 20705, (301) 504-8205; FTS 964-8205
Dr. E. Stang	Department of Horticulture, University of Wisconsin, 1575 Linden Drive, Madison, WI 53706, (608) 262-1268
Dr. E. Sugden	USDA ARS, Honey Bee Research Unit, Subtropical Agric. Research Lab., 2413 E. Hwy 83 Bldg. 205, Weslaco, TX 78596, (512) 969-4870
Dr. J. Tew	Extension Service & OARDC, Ohio State University, 1328 Dover Road, Wooster, OH 44691, (216) 264-3911
Dr. R. Thorp	Entomology Department, College of Environmental Science, University of California, Davis, CA 95616, (916) 752-0482
Dr. J. Vandenberg	USDA ARS, Bee Biology and Systematics Lab, Utah State University, Logan, UT 84322-5310, (801) 750-2524
Mr. P. Yamamoto	Almond Board of California, 13170 Sunny Acres Ave., Turlock, CA 95380, (209) 632-4339
Dr. D. Zimmerman	USDA ARS, 1605 West College Street, P O Box 5674 Univ Sta, Fargo, ND 58105, (701) 239-1370